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(54) Title: TREATMENT PROCESS FOR PROMOTING WEIGHT LOSS EMPLOYING A SUBSTITUTED Δ 5-ANDROSTENE**(57) Abstract**

A method for controlling weight gain or promoting weight loss which includes the step of treating a subject with an effective weight gain controlling or weight loss promoting amount of substituted Δ 5-Androstene which is biologically effective for controlling weight gain or promoting weight loss and biologically ineffective for promoting the synthesis of sex hormones. Steroids believed to provide the desired weight control/weight loss characteristics include: Δ 5-Androstene-3 β ,7 α -diol-17-one, Δ 5-Androstene-3 β -ol-7,17-dione, Δ 5-Androstene-3 β -7 α ,17-triol, Δ 5-Androstene-3 β -17 β -diol-7-one and various derivatives thereof.

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**TREATMENT PROCESS FOR PROMOTING WEIGHT LOSS
EMPLOYING A SUBSTITUTED Δ 5-ANDROSTENE**

5

Field of the Invention

Broadly, the invention relates to the use of steroids for effecting a desired biological response. Specifically, the invention relates to the use of a 10 substituted dehydroepiandrosterone capable of effecting a variety of beneficial biological responses without inducing the formation of androgen and estrogen hormones which is commonly associated with dehydroepiandrosterone treatment.

15

Background

Dehydroepiandrosterone (Δ 5-androstene 3β -hydroxy, 17-one) (hereinafter referenced as DHEA) is a natural steroid produced in the adrenal glands, testes and brain. Dehydroepiandrosterone is an intermediate in the 20 biosynthetic production of estrogen and androgen (sex hormones) from 17α -hydroxy pregnenolone.

Treatment with DHEA is believed to stimulate various biological responses including promoting weight loss and inducing an increase in the production of the sex 25 hormones androgen and estrogen.

The ability of DHEA to promote weight control is believed to be mediated through enhanced thermogenesis (conversion to heat energy rather than chemical energy such as ATP and/or triacylglycerides). The thermogenic effect 30 of DHEA is believed to result from a stimulation in the synthesis of liver thermogenic enzymes such as mitochondrial glycerol 3-phosphate dehydrogenase (G3P-DH) and cytosolic malic enzyme (ME) which tend to reduce the efficiency of energy metabolism.

35 Unfortunately, DHEA is not useful as a therapeutic agent for controlling weight gain/promoting weight loss

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because the dose rate of DHEA necessary to achieve these desired characteristics may also stimulate the production of sex hormones which is associated with various undesired side effects.

5 Accordingly, a therapeutic agent possessing the weight loss characteristic of DHEA without the associated sex hormone stimulating characteristic would be extremely useful.

10 ***Summary of the Invention***

A method for controlling weight gain and/or promoting weight loss which includes the step of treating a subject with an effective weight gain controlling and/or weight loss promoting amount of a substituted $\Delta 5$ -Androstene 15 effective for stimulating the desired biological response while ineffective for inducing the synthesis of sex hormones.

Steroids believed to provide the desired beneficial biological results include:

20 $\Delta 5$ -Androstene- $3\beta,7\alpha$ -diol-17-one
 $\Delta 5$ -Androstene- 3β -ol-7,17-dione
 $\Delta 5$ -Androstene- $3\beta-7\alpha,17$ -triol
 $\Delta 5$ -Androstene- $3\beta-17\beta$ -diol-7-one

25 and derivatives thereof wherein (i) at least one of the hydroxyl groups is esterified with an acid selected from the group consisting of (i) C_{2-22} aliphatic acids that may or may not contain one or more double bonds and may or may not contain branched carbon chains, (ii) 30 C_{7-12} aromatic acids, (iii) C_3 or larger dicarboxylic acids in which only one of the carboxyl groups is esterified to the hydroxyl group(s) on the steroid leaving the second carboxyl group free or in the form of a salt, or (iv) inorganic acids such as sulfuric and phosphoric.

35 These steroids may also be administered as carbamate, enanthates and other derivatives capable of releasing the free steroid in the intestinal tract, the

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blood or in tissues. The desired biological activity is a function of the steroid moiety. Derivation of the moiety may serve a variety of possible functions including stabilization of the steroid, flavoring or obscuring the 5 natural flavor of the steroid, or affecting the rate of absorption of the steroid.

*Detailed Description of the Invention
Including a Best Mode*

10 $\Delta 5$ -Androstene substituted at C-3, C-7 and/or C-17 with a hydroxyl or keto group are biologically effective for controlling weight gain and promoting weight loss without substantial stimulation in the production of sex hormones. Derivatives of these substituted $\Delta 5$ -Androstene 15 in which at least one of the hydroxyl groups is esterified with an acid selected from the group consisting of (i) C₂₋₂₂ aliphatic acids that may or may not contain one or more double bonds and may or may not contain branched carbon chains, (ii) C₇₋₁₂ aromatic acids, (iii) C₃ or larger 20 dicarboxylic acids in which only one of the carboxyl groups is esterified to they hydroxyl group(s) on the steroid leaving the second carboxyl group free or in the form of a salt, or (iv) inorganic acids such as sulfuric and phosphoric, and also believed to possess the desired 25 characteristics.

These steroids may also be administered as carbamate, enanthates and other derivatives capable of

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releasing the free steroid in the intestinal tract, the blood or in tissues. The desired biological activity is a function of the steroid moiety; the derivatizing moiety may serve to stabilize the steroid, to favor or to retard 5 absorption or to obscure its flavor.

Synthesis

Δ^5 -Androstene 3β ,7-diol, 17-one
(7-hydroxy DHEA)

10 Δ^5 -Androstene 3β ,7 α -diol, 17-one (7-hydroxy DHEA) can be synthesized from commercially available DHEA acetate by sequentially synthesizing:

15 Δ^5 -Androstene- 3β hydroxy-17-one
 Δ^5 -Androstene- 3β -hydroxy-7-bromo-17-one
 Δ^5 -Androstene- 3β ,7 α -hydroxy-17-one diacetate
 Δ^5 -Androstene- 3β ,17 α -hydroxy-17-one

15 Δ^5 -Androstene 3β -hydroxy-7-bromo-17-one (7-bromo DHEA) can be synthesized from Δ^5 -Androstene 3β -hydroxy-17-one acetate (DHEA acetate) by reacting the DHEA acetate with a brominating agent such as Dibromantin (1,3 dibromo 5,5 dimethylhydantoin or N-bromo succinimide. 7-bromo DHEA is unstable and must be used immediately in the next step of the process.

20 The 7-bromo DHEA containing an isomeric mixture of 25 7 α -bromo DHEA and 7 β -bromo DHEA may be equilibrated to 7 α -bromo DHEA in accordance with the method described for a cholesterol derivative in Confalone, P.N., Kulesha, I.D., and Uskokovic, M.R. Jour. Org. Chem., vol. 46, pp 1030-1032

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(1981). Briefly the racemic mixture of 7-bromo DHEA is contacted with cold anhydrous LiBr and shielded from light until their stereospecific composition is achieved.

5 $\Delta 5$ -androstene 3β , 7-hydroxy-17-one diacetate (7-hydroxy DHEA diacetate) may be synthesized from the 7-bromo DHEA by reacting the 7-bromo DHEA with a mixture of glacial acetic acid and powdered silver acetate at room temperature in a suitable solvent such as methylene chloride or acetone.

10 $\Delta 5$ -androstene 3β , 7α -hydroxy-17-one diacetate (DHEA) 2 may be synthesized from the 7-hydroxy DHEA diacetate by reacting the 7-hydroxy DHEA diacetate dissolved in methanol with an aqueous solution containing a suitable base such as Na_2CO_3 .

15 The synthesized 7-hydroxy DHEA may then be purified by (i) evaporating the methanol in vacuo, (ii) extracting the 7-hydroxy DHEA into an appropriate organic solvent such as dichloromethane, (iii) evaporating the organic solvent in vacuo, (iv) azeotropically drying the 20 extracted solids containing the 7-hydroxy DHEA with a suitable organic solvent such as ethanol, (v) dissolving the extracted solids in acetone, and then (vi) adding a suitable precipitating agent, such as hexane, to the acetone solution to produce purified crystals of $\Delta 5$ -Androstene $3\beta, 7\alpha$ -diol, 17-one.

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A second crop of $\Delta 5$ -Androstene $3\beta,7\alpha$ -diol, 17-one
crystals may be obtained by cooling the resultant solution
below room temperature.

5.

$\Delta 5$ -Androstene- 3β -ol 7,17-dione
(7-keto DHEA)

$\Delta 5$ -Androstene 3β -ol, 7,17-dione can be synthesized
10 from commercially available DHEA acetate by sequentially
synthesizing:

3β -acetoxy- $\Delta 5$ -androstene-17-one
 3β -acetoxy- $\Delta 5$ -androstene-7,17-one
 $\Delta 5$ -androstene 3β -hydroxy-7,17-one

15 3β -acetoxy- $\Delta 5$ -androstene-7,17-one (7-one DHEA
acetate) can be synthesized from 3β -acetoxy- $\Delta 5$ -androstene-
17-one (DHEA acetate) by reacting the DHEA acetate with the
oxidizing agent CrO_3 in accordance with the procedure
outlined in Fieser, L.F., Jour. Am. Chem. Soc., vol. 75, pp
20 4386-4394 (1953).

$\Delta 5$ -androstene 3β -hydroxy-7,17-dione (7-one DHEA)
can be synthesized from the 7-one acetate and purified by
employing the deesterification and purification steps set
forth above with respect to the synthesis and purification
25 of 7-hydroxy DHEA from 7-hydroxy DHEA diacetate.

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Δ5-Androstene 3β, 7α,17β-triol
(7α-hydroxy Androstenediol)

Δ5-Androstene 3β,7α,17β-triol can be synthesized from commercially available Androstenediol diacetate by 5 sequentially synthesizing:

Δ5-androstene 3β,17β-diol, diacetate
Δ5-androstene 3β,17β-diol-7-bromide, diacetate
Δ5-androstene 3β,7α,17β-triol-3,17-diacetate
Δ5-androstene 3β,7α,17β-triol

10 Δ5-androstene 3β,17β-diol-7-bromide (7-bromo Androstenediol) can be synthesized from the commercially available Δ5-androstene 3β, 17β-diol diacetate (Androstenediol diacetate) by reacting the Androstenediol diacetate with a brominating agent such as Dibromantin (1;3 dibromo 5,5 dimethylhydantion) or N-bromosuccinimide. The 15 synthesized 7-bromo Androstenediol is unstable and must be used immediately.

The 7-bromo Androstenediol contains an isomeric mixture of 7α-bromo Androstenediol and 7β-bromo Androstenediol which can be equilibrated to 7α-bromo Androstenediol in accordance with the method described in 20 Confalone, P.N., Kulesha, I.D., and Uskokovic, M.R. Jour. Org. Chem., vol. 46, pp 1030-1032 (1981). Briefly the racemic mixture of 7-bromo Androstenediol is contacted with 25 anhydrous LiBr and shielded from light until the stereospecific composition is achieved.

Δ5-androstene 3β,7α,17β-triol-3,17-diacetate (7-hydroxy Androstenediol diacetate) may be synthesized from

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the 7-bromo Androstenediol by reacting the 7-bromo Androstenediol with a mixture of glacial acetic acid and silver acetate in a suitable solvent such and methylene chloride or acetone.

5 $\Delta 5$ -androstene $3\beta, 7\alpha, 17\beta$ -triol (7-hydroxy Androstenediol) may by synthesized from the 7-hydroxy Androstenediol diacetate by reacting the 7-hydroxy Androstenediol diacetate in methanol with an aqueous solution containing a suitable base such as Na_2CO_3 .

10 The synthesized 7-hydroxy Androstenediol may then be purified by (i) evaporating the methanol in vacuo, (ii) extracting the 7-hydroxy Androstenediol into an appropriate organic solvent such as dichloromethane, (iii) evaporating the organic solvent in vacuo, (iv) azeotropically drying 15 the extracted solids containing the 7-hydroxy Androstenediol with a suitable organic solvent such as ethanol, (v) dissolving the extracted solids in acetone, and then (vi) adding a suitable precipitating agent, such as hexane, to the acetone solution to produce purified 20 crystals of $\Delta 5$ -Androstene $3\beta, 7\alpha, 17\beta$ -triol.

A second crop of $\Delta 5$ -Androstene $3\beta, 7\alpha, 17\beta$ -triol crystals may be obtained by cooling the resultant solution below room temperature.

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Δ_5 -Androstene $3\beta,17\beta$ -diol, 7-one
(7-keto Androstenediol)

Δ_5 -Androstene $3\beta,17\beta$ -diol-7-one can be
synthesized from commercially available androstenediol

5 diacetate by sequentially synthesizing:

Δ_5 -androstene $3\beta,17\beta$ -diol diacetate
 Δ_5 -androstene $3\beta,17\beta$ -diol-7-one diacetate
 Δ_5 -androstene $3\beta,17\beta$ -diol-7-one

Δ_5 -androstene $3\beta,17\beta$ -diol-7-one diacetate can be
10 synthesized from Δ_5 -androstene $3\beta,17\beta$ -diol diacetate
(Androstenediol diacetate) by reacting the androstenediol
diacetate with the oxidizing agent CrO_3 in accordance with
the procedure outlined in Fieser, L.F., Jour. Am. Chem.
Soc., vol. 75, pp 4386-4394 (1953).

15 Δ_5 -androstene $3\beta,17\beta$ -diol-7-one (7-one
androstenediol) can be synthesized from Δ_5 -androstene
 $3\beta,17\beta$ -diol-7-one diacetate and purified by employing the
deesterification and purification steps set forth above
with respect to the synthesis and purification of 7-hydroxy
20 DHEA from 7-hydroxy DHEA diacetate.

Without intending to be unduly limited thereby, it
is believed that the substituted Δ_5 -Androstene may be
further modified by esterifying one or more of the hydroxyl
groups with any of a variety of organic acids and inorganic
25 acids such as sulfuric or phosphoric acid.

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Treatment

A subject may be treated with the substituted Δ5-Androstene by any of the commonly accepted practices including orally or by injection. It is believed that

5 treatment at a dosage rate of about 0.1 to 2 grams, preferably about 0.5 to 2 grams, steroid per 100 kilograms body weight per day is generally effective for promoting weight loss and/or preventing weight gain. A dose rate of less than 0.1 gram per 100 kilograms bodyweight is believed

10 to be generally ineffective for preventing weight gain while a dose rate of greater than about 2 grams per 100 kilograms bodyweight increases the cost of the treatment without providing a corresponding benefit in performance. The optimum dose rate to be administered to a subject is case

15 specific as the optimum dose rate depends upon several factors including current body composition (percent fat), the desired effect (weight gain prevention versus weight loss), eating habits of the individual (daily caloric intake), and the like. As would be expected, the dose rate

20 provided to a subject for the purpose of promoting weight loss will be greater than that necessary to promote weight maintenance assuming identical caloric intake under each program.

Without intending to be limited thereby, we

25 believe that the substituted Δ5-Androstene are metabolic intermediates between the conversion of DHEA to a

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intermediate between the conversion of DHEA to a metabolite(s) actually responsible for enhancing the production of thermogenic enzymes such as glycerol 3-phosphate dehydrogenase and malic enzyme.

5 The subject may be treated with a steroid on any desired schedule. It is anticipated that the steroid will be effective for preventing weight gain and/or promoting weight loss not only while actively present within the body, but also for as long as the concentration of the 10 induced thermogenic enzyme(s) remain elevated. At the present time, the duration of effectiveness for the steroid is not fully appreciated. However, it is believed that the steroid is not stored within the body and will be substantially removed and/or deactivated within days after 15 administration. Accordingly, the subject should be conveniently treated every day for optimum performance but may be treated less frequency such as every other day or week when less than maximum performance is acceptable. For example, a subject placed on a weight maintenance program 20 may require treatment with the steroid thermogenic enzyme(s) are not retained during the entire period between treatments as the weight loss occurring within the first few days after treatment counterbalances any weight gain occurring during the remaining days between treatments.

25 As is apparent from the factors which affect dosage and dose rate, each particular subject should be

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carefully and frequently reviewed and the dosage and/or dose rate altered in accordance with the particular situation.

5

Experimental

Example I

Synthesis

Δ5-Androstene 3β,7α-diol-17-one

10

(Step 1) Into a two liter, triple neck, round bottom flask equipped with a magnetic stirrer and a reflux condenser was placed 1000 ml hexane (b.p 69-71°), 10 grams (0.03 moles) DHEA acetate and 13.6 grams (0.16 moles)

15 NaHCO₃ to form a first solution. The first solution was placed under a N₂ atmosphere and heated under constant agitation to reflux. Into the refluxing first solution was added 6.11 grams (0.021 moles) Dibromantin (1,3 dibromo 5,5 dimethylhydantion) as a brominating agent to form a second 20 solution. The second solution gradually turned orange after which it rapidly turned a pale white/yellow. The second solution was refluxed for 30 minutes, cooled to room temperature and filtered through a sintered glass funnel. The residue was rinsed with 50 ml dichloromethane and the 25 combined filtrate rotovapped to dryness at a temperature of less than 35°C. The dry filtrate (Δ5-Androstene 3β,7α-diol-17-one) is unstable to storage and was used immediately in step two.

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(Step 2) The dry filtrate was resolubilized in 80 ml of dichloromethane in a one liter stoppered flask equipped with a magnetic stirrer and placed in an ice bath. Into the resolubilized filtrate was added 8 grams anhydrous 5 LiBr in 320 ml ice-cold acetone to form a third solution. The third solution was shielded from light and stirred continuously for three hours. The resulting solution was predominantly (Δ^5 -Androstene 3β -ol- 7α -bromo-17-one) was allowed to warm briefly and used immediately in step three.

(Step 3) Into a 500 ml flask equipped with a magnetic stirrer was placed 320 ml dichloromethane, 80 ml glacial acetic acid, and 26 grams of silver acetate to form a first suspension. The first suspension was stirred continuously for 20 minutes at room temperature. The 15 stirred first suspension was added under constant agitation into the warmed solution of predominantly Δ^5 -Androstene 3β -ol- 7α -bromo-17-one to form a second suspension. The second suspension was constantly stirred for 30 minutes at room temperature during which the suspension was filtered 20 through a sintered glass funnel to produce a solid fraction. The filtered solid fraction was rinsed with 100 ml dichloromethane. The filtrate was extracted three times with 1000 ml of water, neutralized with 1000 ml of a 5% NaHCO_3 solution, and extracted twice more with water. The 25 organic solution containing Δ^5 -Androstene 3β - 17α -diol-17-one diacetate was then rotovapped to dryness.

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(Step 4) The dried extracted solids were resolubilized in 500 ml methanol in a one liter, triple necked flask equipped with a magnetic stirrer and a reflux condenser to form a fourth solution. The fourth solution 5 was placed under a N₂ atmosphere and heated under constant stirring to reflux. Into the fourth solution was added 250 ml of a 5% aqueous solution of Na₂CO₃ to form a fifth solution. The fifth solution was refluxed under constant agitation for 45 minutes. The methanol was rotovapped off 10 and the aqueous fifth solution carefully brought to a pH of 7 with an appropriate amount of glacial acetic acid. The neutralized fifth solution was extracted twice with 100 ml of dichloromethane. The dichloromethane solution of Δ5-Androstene 3β,7α-diol-17-one was rotovapped to near 15 dryness, azeotropically dried with absolute ethanol, and then azeotropically dried twice with acetone. Warm acetone was added to the dried extracted solids until the solids were completely dissolved to form a sixth solution. Hexane was added to the sixth solution until the solution began to 20 cloud at which time crystals of Δ5-Androstene 3β-7α-diol-17-one began to form at room temperature.

A second crop of Δ5-Androstene 3β-7α-diol-17-one crystals was obtained by cooling the remaining sixth solution.

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The product melts at about 187-189°C and when recrystallized from acetone/hexane melts at about 192-193°C.

5 *Example II*

Synthesis
Δ5-Androstene 3β-7(αβ)-diol-17-one

Δ5-Androstene 3β-7α-diol-17-one was manufactured in accordance with the procedure set forth in Example I except that Step 2 was eliminated with the dried filtrated from Step I simply resolubilized in the 80 ml of dichloromethane in preparation for Step 3.

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Example III

Synthesis
 $\Delta 5$ -Androstene 3β -ol-7,17-dione

5 (Step 1) Into a 50 ml flask equipped with a magnetic stirrer and a water bath was placed 6.5 ml acetic anhydride, 23 ml acetic acid, 1.7 grams sodium acetate, and 2 grams DHEA acetate to form a first mixture. Into the first mixture was added 2 grams chromium trioxide over a
10 thirty minute period to form a second mixture. The first mixture was maintained at a constant temperature of 56-58°C and continuously agitated during addition of the chromium trioxide. The second mixture was maintained at 56-58°C and continuously agitated for an additional hour after which
15 the second mixture was cooled and slowly poured under continuous agitation into 600 ml of ice water to form a precipitate. The flocculent precipitate was collected on a sintered glass funnel and washed with water until no longer green. After drying in vacuo over P_2O_5 the product was
20 dissolved in methanol and recrystallized to yield substantially pure $\Delta 5$ -Androstene 3β -acetoxy-7,17-dione having a melting point of about 191-192°C.

 (Step 2) The precipitate was resolubilized in 500 ml of methanol in a one liter, triple necked, round bottom
25 flask equipped with a magnetic stirrer and reflux condenser to form a third solution. The third solution was placed under a N_2 atmosphere and heated under constant agitation

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to reflux. Into the third solution was added 250 ml of a 5% solution of Na_2CO_3 to form a fourth solution. The fourth solution was refluxed under constant agitation for 45 minutes. The methanol was rotovapped off and the 5 aqueous fourth solution carefully brought to a pH of 7 with an appropriate amount of glacial acetic acid. The neutralized fourth solution was extracted with two 100 ml portions of dichloromethane, and two portions combined, and the dichloromethane evaporated in vacuo. The extracted 10 solids were then azeotropically dried first with absolute ethanol and then with two separate portions of acetone. Methanol was added to the dried extracted solids until the solids were completely dissolved to form a fifth solution. Hexane was added to the fifth solution until the solution 15 began to cloud at which time crystals of $\Delta 5$ -Androstene 3β -ol-7,17-dione began to form at room temperature.

A second crop of $\Delta 5$ -Androstene 3β -ol-7,17-dione crystals was obtained by cooling the remaining sixth solution.

20 The resultant product had a melting point of about 235-238°C.

Example IV

25 Synthesis
 $\Delta 5$ -Androstene 3β ,7,17-triol
(Step 1) Into a two liter round bottom flask equipped with a magnetic stirrer and a reflux condenser was

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placed 1000 ml hexane (b.p 69-71°), 10 grams (0.03 moles) Δ5-Androstene 3 β -17 β -diol diacetate and 13.6 grams (0.16 moles) NaHCO₃ to form a first solution. The first solution was placed under a N₂ atmosphere and heated under constant agitation to reflux. Into the refluxing first solution was added 6.11 g (0.021 moles) Dibromantin (1,3-dibromo-5,5-dimethylhydantion) as a brominating agent to form a second solution. The second solution gradually turned orange after which it rapidly turned a pale white/light yellow.

10 The second solution was refluxed for 30 minutes, cooled to room temperature and filtered through a sintered glass funnel. The residue was rinsed with 50 ml dichloromethane and rotovapped to dryness at a temperature of less than 35°C. The dry filtrate (Δ5-Androstene 3 β -17 β -diol-7-bromide) is unstable to storage and was used immediately in step two.

15

(Step 2) The dried filtrate was resolubilized in 80 ml of dichloromethane in a flask equipped with a magnetic stirrer and placed in an ice bath. Into the 20 resolubilized filtrate was added 8 g anhydrous LiBr in 320 ml ice-cold acetone to form a third solution. The third solution was shielded from light and stirred continuously for three hours. The resulting solution of predominantly Δ5-Androstene 3 β -17 β -diol-7 α -bromide was allowed to warm 25 briefly and used immediately.

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(Step 3) Into a 500 ml flask equipped with a magnetic stirrer was placed 320 ml methylene chloride, 80 ml glacial acetic acid, and 26 grams silver acetate to form a first suspension. The first suspension was stirred 5 continuously for 20 minutes at room temperature. The stirred first suspension was added under constant agitation to the warmed solution of predominantly $\Delta 5$ -Androstene 3β - 17β -diol- 7α -bromide to form a second suspension. The second suspension was constantly stirred for 30 minutes at 10 room temperature during which the suspension gradually darkened and was then filtered through a sintered glass funnel. The residual solids retained on the glass filter were rinsed with 10 ml dichloromethane. The filtrate was extracted three times with 1000 ml of water, neutralized 15 with 1000 ml of a 5% NaHCO_3 solution, and then extracted from the filtrate ($\Delta 5$ -Androstene $3\beta, 7\alpha, 17\beta$ -triol- $3, 17$ -diacetate) were rotovapped to dryness.

(Step 4) The dried extracted solids were resolubilized in 500 ml methanol contained in a one liter, 20 triple necked, round bottom flask equipped with a magnetic stirrer and a reflux condenser to form a fourth solution. The fourth solution was placed under a N_2 atmosphere and heated under constant agitation to reflux. Into the fourth solution was added 250 ml of a 5% aqueous solution of 25 Na_2CO_3 to form a fifth solution. The fifth solution was refluxed under constant agitation for 45 minutes. The

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methanol was rotovapped off and the aqueous fifth solution carefully brought to a pH of 7 with an appropriate amount of glacial acetic acid. The neutralized fifth solution was extracted twice with 100 ml dichloromethane and the 5 combined extract evaporated in vacuo. The extracted solids (Δ^5 -Androstene $3\beta,7\alpha,17\beta$ -triol) were azeotropically dried with absolute ethanol and then twice with acetone. Warm acetone was added to the dried extracted solids until the solids were completely dissolved to form a sixth solution. 10 Hexane was added to the sixth solution until the solution began to cloud at which time crystals of Δ^5 -Androstene $3\beta,7\alpha,17\beta$ -triol began to form at room temperature. 15 A second crop of Δ^5 -Androstene $3\beta,7\alpha,17\beta$ -triol crystals was obtained by cooling the remaining sixth solution.

Example V

Synthesis

Δ^5 -Androstene $3\beta,7(\alpha\beta),17\beta$ -triol

20 Δ^5 -Androstene $3\beta,7(\alpha\beta),17\beta$ -triol was manufactured in accordance with the procedure set forth in Example III except that Step 2 was eliminated with the dried filtrated from Step I simply resolubilized in the 80 ml of methylene 25 chloride in preparation for Step 3.

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Example VI

Synthesis

Δ^5 -Androstene $3\beta,17(\beta)$ -diol-7-one

5 (Step 1) Into a 50 ml flask equipped with a magnetic stirrer and a water bath was placed 6.5 ml acetic anhydride, 23 ml acetic acid, 1.7 grams sodium acetate, and 2 grams androstanediol diacetate to form a first mixture. 10 Into the first mixture was added 2 grams chromium trioxide over a thirty minute period to form a second mixture. The first mixture was maintained at a constant temperature of 56-58°C and continuously agitated during addition of the chromium trioxide. The second mixture was maintained at 56-58°C and continuously agitated for an additional hour 15 after which the second mixture was cooled and slowly poured under continuous agitation into 600 ml of ice water to form a precipitate. The flocculent precipitate was filtered through a sintered glass funnel, washed with water until no longer green and dried in vacuo.

20 (Step 2) The dried precipitate was resolubilized in 500 ml of methanol in a one liter, round bottom flask equipped with a magnetic stirrer and reflux condenser to form a third solution. The third solution was placed under a N_2 atmosphere and heated under constant agitation to 25 reflux. Into the third solution was added 250 ml of a 5% aqueous solution of Na_2CO_3 to form a fourth solution. The fourth solution was refluxed under constant agitation for 45 minutes. The methanol was rotovapped off and the

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aqueous fourth solution carefully brought to a pH of 7 with an appropriate amount of glacial acetic acid. The neutralized fourth solution was extracted twice with 100 ml portions of dichloromethane and the combined extract 5 evaporated in vacuo. The extracted solids were then azeotropically dried first with absolute ethanol and then twice with acetone. Methanol was added to the dried extracted solids until the solids were completely dissolved to form a fifth solution. Hexane was added to the fifth 10 solution until the solution began to cloud at which time crystals of $\Delta 5$ -Androstene $3\beta 17\beta$ -diol-7-one began to form at room temperature.

The resultant product had a melting point of about 200-202°C.

15

Example VII

Enzymatic Activity
Protocol

20 Administration of Hormone: Male Sprague Dawley rats weighing 125-150 gm were obtained from Sasco Inc. of Oregon, WI. The rats were allowed free access to water and Purina Rat Chow pellets for the first day after arrival. Administration of the steroids began on day two. The 25 steroids were either administered orally (combined with the Purina Rat Chow) or injected intraperitoneal as set forth in Table 1 for 6 days.

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Preparation of Liver Mitochondria and Cytosol. The treated rats were sacrificed by decapitation after 6 days of treatment. The livers were excised, placed in 10 ml of a buffer consisting of 250 mM mannitol, 70 mM sucrose, and 3 5 mM Hepes (hereinafter MSH buffer) at pH 7.4, weighted, removed from the buffer, minced with scissors, washed with MSH buffer, suspended in MSH buffer at a ratio of 1 gram minced liver to 5 ml MSH buffer at a ratio of 1 gram minced liver to 5 ml MSH buffer, and homogenized with a Potter-10 Elvehjem rotary homogenizer.

The Mitochondria fraction was prepared by the method described in Johnson, D. and Lardy, H.A., Methods Enzymology, vol. 10, pp 94-96 (1967) which is hereby incorporated by reference. Briefly, liver homogenate was 15 centrifuged in a Beckman Model J2-21 centrifuge, JA-20 rotor at 750g for 10 minutes and the resulting supernatant solution centrifuged at 15,000g for an additional 10 minutes. The resulting mitochondrial pellets were washed twice with MSH buffer, resuspended in 0.8 to 1 ml of a 35 20 wt% aqueous glycerol solution, and stored at -70°C.

The Cytosolic fraction was obtained by recentrifuging the previously centrifuged supernatant solution at 100,000g for 30 minutes in a Beckman Model L2 ultracentrifuge, type 40 rotor. The resultant supernatant 25 solution was stored at -70°C.

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Protein concentrations in the resultant preparations were determined by the Biuret method described in Layne E., Methods Enzymology, vol. 3, pp 450451 (1957) which is hereby incorporated by reference. Briefly, the 5 protein concentrations were determined by treating a dilute protein solution with copper tartrate solution and measuring the optical density at 540 nm.

Enzyme Assays. Mitochondrial G3P-DH activity was measured by the method described in Wernette, M.E., Ochs, 10 R.S., and Lardy, H.A., J. Biol. Chem., vol. 256, pp 12767-12771 (1981) which is a modified version of the method described in Gardner, R.S., Anal. Biochem., vol. 59, pp 272-276 (1974). Both references are hereby incorporated by reference. Briefly, aliquots of the previously prepared 15 mitochondria containing 0.1 to 0.2 mg of protein were incubated in a test tube containing 50 mM sn-glycerol-3-P, 50 mM potassium phosphate (pH 7.0), 1 mM KCN, and 0.2% p-iodonitrotetrazolium violet in a total volume of 0.4 ml for 30 minutes at 37°C. The incubating mitochondria were 20 continuously agitated during the incubation period by a Dubnoff shaker agitated at 100 cycles/min. Incubation was ceased by the addition of 0.6 ml of 1 M acetic acid to the test tube. The iodoformazan formed during the incubation period was extracted into 2 ml of ethyl acetate by adding 25 the ethyl acetate to the test tube, mixing thoroughly, then decanting the ethyl acetate containing the iodoformazan

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from the test tube. The optical densities of the iodoformazan containing ethyl acetate layers were read at 490 nm by means of an On Line Instrument Systems, Model 3820 Data System, Spectrophotometry, Cary - 15, Version 4.08. An extinction coefficient value of $2.01 \times 10^4 / (\text{M cm})$ for the iodoformazan product in ethyl acetate was used to calculate enzyme activities.

Cytosolic malic enzyme activity was measured in accordance with the method described in Hsu, R.Y. and 10 Lardy, H.A., Methods Enzymol., vol. 8, pp 230-235 (1967). Briefly, aliquots of the previously prepared cytosol containing 0.1 to 0.5 mg of protein were incubated in a test tube containing 0.8 mM malate, 67 mM triethanolamine buffer (pH 7.4), 4 mM MnCl₂, and 0.2 mM NADP in a total 15 volume of 1 ml for 3 min at 26°C. the incubating cytosol was continuously agitated during the incubation period by a Dubnoff shaker agitated at 100 cycles/min. Activity of malic enzyme was calculated from the rate of change in optical density measured at 340 nm from 0.5 to 2 minutes 20 with an On Line Instrument Systems, Model 3820 Data System, Spectrophotometry, Cary - 15, Version 4.08.

Results of several tests conducted in accordance with the protocol established above are set forth in Table 1.

Table 1
(Enzyme induction in rat liver by C₁₉ steroids)

Steroid ^a	# rats	wt % steroid in diet	G3P-DH (Z control) ¹	Malic Enzyme (Z control) ¹
Δ5 Androstene 3β-ol-17-one	(DHEA)	1	0.2	380 512
		29	0.1	265 ---
		27	0.1	394 ---
		12	0.05	251 337
		3	0.01	139 64
Δ5 Androstene 3β,7α-ol-17-one	(7α-dihydroxy DHEA)	2	0.05	292 423
		2	0.033	308 374
Δ5 Androstene 3β,7α,19-ol-17-one	(7α,19-dihydroxy DHEA)	3	0.1	117 118
Δ5-Androstene 3β-ol-7,17-one	(7-keto DHEA)	3	0.1	220 350
		5	0.05	439 449
		2	0.0575	224 341
		3	0.01	183 229
Δ5-Androstene-3β-ol-7,17-one acetate	(7-keto DHEA acetate)	3	0.115	261 447
Δ5-Androstene 3β-ol-7-methyl-17-one	(7-methyl DHEA)	3	0.1	91 121
Δ5-Androstene 3β,7α,17β-triol		2	0.1	227 611
		2	0.01	99 108
Δ5-Androstene 3β-17β-diol-7-one		2	0.1	286 1030
		3	0.05	360 305
		4	0.01	180 175
Δ5-Androstene 3β,17β-diol 7-one diacetate		3	0.13	232 452
		2	0.01	173 119

¹ Control activity based upon enzyme activity in the livers of rats fed with the stock diet without hormone supplement. IN each assay control rats fed only stock diet without hormone supplement were compared with test rats fed stock diet supplement with indicated wt% hormone.

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We claim:

1. A treatment method comprising the step of treating a subject with an effective weight gain preventative amount of a steroid selected from the group consisting of substituted Δ 5-Androstenes which are effective for inhibiting weight gain without increasing the synthesis of sex hormones.

10 2. The treatment of claim 1 wherein the step of treating a subject comprises the step of treating a mammal.

15 3. The treatment method of claim 2 wherein the step of treating a mammal comprises the step of treating a human.

20 4. The treatment method of claim 1 wherein the step of treating a subject with an effective weight gain preventative amount of a steroid comprises the step of treating the subject with about 0.1 to about 2 grams of steroid per 100 kg body weight per day.

25 5. The treatment of claim 1 wherein the step of treating a subject with an effective weight gain preventative amount of a steroid comprises the step of treating the subject with about 0.5 to 2 grams of the steroid per 100 kg body weight per day.

30 6. The treatment method of claim 3 wherein the step of treating a human subject with an effective weight gain preventative amount of a steroid comprises the step of treating the human subject with about 0.1 to 2 grams of the steroid per 100 kg body weight per day.

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7. The treatment method of claim 4 wherein the step of treating the subject with a weight gain preventative steroid comprises the step of administering a therapeutic dose of the steroid to the subject at least once a week.

5

8. The treatment method of claim 4 wherein the step of treating the subject with a weight gain preventative steroid comprises the step of administering a therapeutic dose of the steroid to the subject at least once a day.

10

9. The treatment method of claim 1 wherein the step of treating the subject with a weight gain preventative steroid comprises the step of injecting the subject with the steroid.

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10. The treatment method of claim 1 wherein the step of treating the subject with a weight gain preventative steroid comprises the step of ingesting the steroid.

20

11. The treatment method of claim 1 wherein the step of treating the subject with a weight gain preventative steroid comprises the step of treating the subject with a $\Delta 5$ -Androstene substituted at the C₇ position.

25

12. The treatment method of claim 11 wherein the step of treating the subject with a $\Delta 5$ -Androstene substituted at the C₇ position with a substituent selected from the group consisting of a hydroxy and a keto group.

30

13. The treatment method of claim 1 wherein the step of treating a subject with an effective weight gain preventative amount of a steroid comprises the step of treating the subject with a substituted

dehydroepiandrosterone which is effective for inhibiting weight gain without substantially increasing the synthesis of sex hormones.

5 14. The treatment method of claim 1 wherein the step of treating the subject with weight gain preventative steroid comprises the step of treating the subject with a dehydroepiandrosterone substituted at the C₇ position.

10 15. The treatment method of claim 14 wherein the step of treating the subject with a C₇ substituted dehydroepiandrosterone comprises the step of treating the subject with a substituted dehydroepiandrosterone selected from the group consisting of 7-hydroxy dehydroepiandrosterone and 7-keto dehydroepiandrosterone.

16. The treatment method of claim 1 wherein the step of treating the subject with a weight gain preventative steroid comprises the step of treating the subject with a steroid selected from the group consisting of Δ 5-Androstene 3 β ,7 α -diol-17-one; Δ 5-Androstene 3 β -hydroxy-7,17-dione; Δ 5-Androstene 3 β ,7 α ,17 β -triol; Δ 5-Androstene 3 β ,17 β -diol-7-one and derivatives thereof wherein at least one of the hydroxyl groups is esterified with an acid selected from the group selected from the group consisting of (i) a C₂ to C₂₂ aliphatic acid, (ii) a C₇₋₁₂ aromatic acid, iii a C₃ or greater dicarboxylic acid in which only one of the carboxyl groups is esterified to the hydroxyl group(s) on the steroid, and (iv) an inorganic acid.

30 17. A treatment method comprising the step of treating an overweight subject with an effective weight reduction promoting amount of a substituted Δ 5-Androstene wherein the substituted Δ 5-Androstene is effective for promoting weight

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loss without substantially increasing the synthesis of sex hormones.

18. A method of treating obesity comprising the step
5 of treating an obese subject with a therapeutic amount of a substituted $\Delta 5$ -Androstene wherein the substituted $\Delta 5$ -Androstene is effective for promoting weight loss without substantially increasing the synthesis of sex hormones.

10 19. A treatment procedure effective for promoting weight loss which comprises the step of treating an overweight subject with an effective weight reduction promoting amount of a substituted $\Delta 5$ -Androstene wherein the substituted $\Delta 5$ -Androstene is biologically functional for
15 promoting weight loss and substantially biologically ineffectual for promoting the synthesis of sex hormones.

20. A treatment procedure comprising the step of treating a subject with an effective weight reduction
20 promoting amount of a substituted $\Delta 5$ -Androstene wherein the substituted $\Delta 5$ -Androstene is effective for increasing the in vivo concentration of a thermogenic enzyme without substantially increasing the in vivo concentration of sex hormones.

25

21. The procedure of claim 20 wherein the step of treating a subject with an effective weight reduction promoting amount of a substituted $\Delta 5$ -Androstene comprises the step of treating the subject with a substituted $\Delta 5$ -Androstene which is effective for increasing the in vivo concentration of a thermogenic enzyme selected from the group consisting of glycerol 3-phosphate dehydrogenase and malic enzyme.

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22. A biologically active steroid effective for inhibiting weight gain without promoting the synthesis of sex hormones comprising a steroid selected from the group consisting of $\Delta 5$ -Androstene $3\beta, 7\alpha, 17\beta$ -triol and derivatives 5 of $\Delta 5$ -Androstene $3\beta, 7\alpha, 17\beta$ -triol wherein at least one of the hydroxyl groups is esterified with an acid selected from the group consisting of (i) a C_2 to C_{22} aliphatic acid, (ii) a C_{7-12} aromatic acid, (iii) a C_3 or greater 10 dicarboxylic acid in which only one of the carboxyl groups is esterified to the hydroxyl group(s) on the steroid, and (iv) an inorganic acid.

23. A biologically active steroid effective for inhibiting weight gain without substantially promoting the 15 synthesis of sex hormones comprising a steroid selected from the group consisting of $\Delta 5$ -Androstene $3\beta, 17\beta$ diol-7 one and derivatives thereof wherein at least one of the hydroxyl groups is esterified with an acid selected from the group consisting of (i) a C_2 to C_{22} aliphatic acid, (ii) 20 a C_{7-12} aromatic acids, (iii) a C_3 or greater dicarboxylic acid in which only one of the carboxyl groups is esterified to the hydroxyl group(s) on the steroid, and (iv) an inorganic acid.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/06147

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all):

According to International Patent Classification (IPC) or to both National Classification and IPC

US CL: 514/177,178 552/502,619,620,623

IPC(5): A01N 45/00 C07J 53/00

II. FIELDS SEARCHED

Minimum Documentation Searched:

Classification System	Classification Symbols
U.S.	514/177,178, 552/502,619,620,623 CAS ON LINE AND APS
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched:	

III. DOCUMENTS CONSIDERED TO BE RELEVANT:

Category	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	US, A, 4,898,694 06 FEBRUARY 1989 -(SCHWARTZ A.G. ET AL) Abstract, column 2, lines 40-64, column 4, line 55 to column 10, line 31.	1-23
Y	US, A, 4,897,390 30 JANUARY (RUHE) Abstract, column 2, line 4 to column 5, line 46.	1-23
Y	US, A, 4,518,595 21 MAY 1985 (COLEMAN ET AL.) Abstract, column 2, line 5 to column 4, line 25.	1-23

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"A" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search

Date of Making of this International Search Report

25 NOVEMBER 1991

13 DEC 1991

International Searching Authority

Signature of Authorized Officer

RO/US

T.J. CRIARES

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